In the bottom of the air-stream flow along the coarse sands and fine gravels, almost solidly it seems, for a height of a foot or two from the ground. Above this basal stratum are the fine sands which usually reach to the height of a man. Higher is the dark dense dust cloud reaching up into the thin atmosphere for a distance of a mile or more. Viewed from the tops of mountains that have greater elevation the dense dust cloud lies like a thundercloud all around as sharply distinguished from the clear upper air as is a sheet of water. Unlike the lazy mist cloud all is rapid motion. The dust-ladened stream is rushing along as some vast mountain torrent.

The "dust storm" or "sand storm" is in reality as much a transportative agent as any river. Matched with a large river it is a titan among flowing, sediment-ladened currents. Its width is 200 to 300 miles instead of only one as in the case of the largest watercourses. It sweeps along at a pace of 40 miles an hour instead of barely three or four miles. It carries along a hundred thousand times more sedimentative materials, the great bulk of which is soon borne entirely out of the arid country into the semiarid and humid lands far beyond. The tremendous volume of this deflated rock waste is amply attested by the enormous loess formations, the broad expanses of black soils of the steppes and prairies, and the extensive beds of plains marls which are displayed in so many parts of the world, especially on the lee sides of deserts. Epeirotic deposits [1] of this origin are only beginning to receive the attention that they merit.

Owing to the fact that the wind sweeps up its chips as fast as it cuts them the magnitude of eolic erosion is at first difficult to measure with any great degree of accuracy. Except under specially favorable conditions definite figures can not always be given. Only when a desert chances to have somewhere on its boundaries remnants of old peneplains highly uplifted, may the extent of regional depletion be closely estimated. As do moist lands under the influences of stream activities, so arid regions soon develop strong contrasts of surface relief under wind action. The belts of weak rocks are first profoundly worn down, leaving the hard rockmasses protruding as mountains. In a region of uniform flat-lying strata the relief contrasts are not always conspicuous. When, however, there are rock-beds of great thickness, alternating hard and soft members, with close patterned mountain structures as in the arid lands of the western United States, differential relief effects attain maximum extremes. In this tract it is that the extreme youthfulness of the lofty desert mountains is at once impressed with amazing vividness upon the mind of the observer fresh from his pluvial homeland.

When once plainly discriminated, wind-graved relief expression is seldom mistaken for any other kind. Its individuality is very strong. Wind-beveled surfaces are smoother than water-formed plains possibly can be. The rock-floors which characterize so many desert plains are phenomena as novel as they are unexpected. Desert ranges rising abruptly out of the plains about impart characteristic form to the enisled landscape. The girdled mountain attests the vigor of natural sand-blast action, and its maximum effectiveness at the plain line. Plateau plains of the desert manifestly represent former levels of the general plains surface. The notable absence of foothills around the mountain ranges appears to be an idiosyncrasy of arid lands. The planation process takes place uphill as well as down; antigravitational gradation is unknown where streams erode. The high gradients of the intermont plains and the strong pitch of the valley axes which are displayed on every hand are not possible in regions where water action is directly the reverse of plains-forming. Of minor features attributable to wind abrasion in the lands of little rain, there are a multitude that have been ascribed to normal water corrasion but that are now known never to have been touched by stream. Upon all these the wind marks, when once pointed out are unmistakable.

It so happens that the great arid tract of western America has near its borders abundant traces of a former baselevel plain [peneplain] now raised more than 2 miles above sealevel. The attainment of its present position is regarded as having taken place in late Tertiary times. It no doubt once extended over all this desert region, at a level somewhat above the tops of most of the present mountains. Since desert conditions began to set in about the same time there is every reason to believe that the magnitude of the erosion is represented by the difference between this old peneplain level and the present plains level—an interval of 5,000 or 6,000 feet—or something over 1 mile of thickness over an area equal to almost one-quarter of the entire United States. There are many considerations supporting the assumption that this area before uplift was a vast plain and not a mountainous district when arid climate was inaugurated. The inappreciable aid of stream corrasion in this prodigious regional depletion is supported by the very fact of the prevalence of aridity. This region is one of the best extant demonstrating beyond peradventure the almost boundless potency of the wind as an epicene power in re-forming the face of the earth.

Thus under favorable climatic conditions of aridity such as prevail to-day over nearly one-half of the entire land surface of our globe wind-scour is the chief agency of provincial leveling and lowering far more rapid and efficacious than any general erosion work by rain or ocean.

[1] Deposits originating within and stopping within the boundaries of the dry lands.—C. A., jr.

551.524 : 551.501 (485)

REDUCTION OF AIR TEMPERATURES AT SWEDISH STATIONS TO A TRUE MEAN.[1]

By NILS EKHOLM.

How far the material presented in this paper applies to American conditions is questionable. The experience of the Signal Service indicated that it was impracticable to require more than maximum and minimum temperature readings from its cooperative observers if satisfactory records were to be obtained in large numbers. In practice it has appeared that the mean temperatures from ½(max.+min.) form satisfactory planes of reference for comparison between different places and between different times at the same place, although the values thus obtained are almost always considerably higher than the means of the hourly observations. Charts and tables showing the corrections to be applied to means from different combinations of observation hours that have been used in the United States were published by Prof. F. H. Bigelow in United States Weather Bureau Bulletin S (Washington, 1909).

The accompanying abstract of Ekholm's paper is here presented in order to show the kind of study carried on in other countries; and also to emphasize the known fact that the mean temperatures universally employed in this country are convenient reference points rather than strictly true means.

The formulæ quoted are, for convenience, numbered consecutively in parentheses ( ); the designations used in Ekholm's original paper appear in brackets [ ].—*W. G. Reed.*

To obtain the true mean air temperature during any space of time hourly readings or better continuous autographic records are necessary. In the absence of

[1] Beräkning av luftens månadsmedeltemperatur vid de svenska meteorologiska stationerna. (Calcul de la température moyenne de l'air aux stations météorologiques suédoises.) *Bihang till meteorologiska iakttagelser i Sverige, bd. 56, 1914.* (Appendice aux observations météorologiques suédoises, vol. 56, 1914. [Swedish and French.] Stockholm, 1916. 111 p. f° *Abstracted* for the REVIEW.

such records the only satisfactory method consists in applying a correction to the mean deduced from the observations, of which the following are examples:

$$t_m = \tfrac{1}{3}(t_7 + t_{13} + t_{21}) + c_3 \qquad (1) \quad [3]$$
$$t_m = \tfrac{1}{2}(t_8 + t_{20}) + c_7 \qquad (2) \quad [7]$$

where t_m is the true mean, t_7, t_8, etc., are the means at the hours indicated by the inferior figures (8 = 8 a. m., 20 = 8 p. m., etc.) and c_3 and c_7 are constants calculated separately for each month of the year for each station where hourly observations are available. There are, of course, many similar formulæ which have been studied in detail for various stations in Europe. To comply with the Swedish observation hours, 8^h, 14^h, and 21^h (8^a, 2^p, and 9^p) the following formula has been devised:

$$t_m = \tfrac{1}{3}(t_8 + t_{14} + t_{21}) + c_{10} \qquad (3) \quad [10]$$

Prof. Erik Edlund devised the following formula in 1859 for reductions at Swedish stations

$$t_m = \tfrac{1}{7}(t_8 + t_{14} + 5t_{21}) + c_{11} \qquad (4) \quad [11]$$

because his studies led him to believe that in this case $c = 0$. The Swedish observations up to 1913 were reduced by this formula and published by the Royal Academy of Sciences.

Although the fact has not been emphasized it is obvious that considerable errors may be introduced unless the observation hours refer to local time at the station. The local time of each station was employed from 1859 to 1878; from 1879 to 1899, Swedish Standard Time (mean civil time of the Stockholm Observatory) was used, and since 1900 Central European Time (one hour earlier than G.M.T.). The result is that the observations vary from about 15 minutes before to about 36 minutes after the corresponding local time. These changes of hour probably introduce considerable errors, at least in the warmer months, in the means calculated by Edlund's formula, which gives to the observation at 21^h a weight of five times that of each of the others. To obviate this difference various attempts have been made to determine coefficients for the means for each observation hour, so that c shall still remain equal to 0.

There are now available for a study of this relation hourly values from the following five observatories:

Station.	Latitude N.		Longitude E.		Altitude.	Time of observation.	Years of record.
	°	′	°	′	*meters*		
Vassijaure...	68	25	18	11.0	506	12^m 44^s after local time...........	*1905–1915
Abisko......	68	21	18	47.0	388.5	15^m 30^s after local time	1913–1915
Upsala......	59	51	17	35.5	24.0	10^m 30^s after local time...........	1896–1913
Kristiania...	59	55	10	43.0	22.5	Local time....................	1896–1913
Hamburg...	53	33	9	58.5	26.0	Local time....................	1899–1909

* With several breaks.

A detailed comparison of the means of the 24 hourly observations with those deduced by the various formulæ hitherto suggested, shows that all are subject to errors too large to permit true values to be deduced by their use, especially for the summer months. The best of these formulæ is

$$t_m = pt_8 + qt_{14} + rt_{21} \qquad (5) \quad [12]$$

where p, q, and r are coefficients and

$$p + q + r = 1 \qquad (6) \quad [13]$$

Rubenson has stated this formula as follows:

$$t_m = pt_8 + qt_{14} + rt_{21} + st_n + xt_x \qquad (7) \quad [12\ \text{quater}]$$

where t_n is the mean of the daily minima, t_x is the mean of the daily maxima, and p, q, r, s, x, are constants, which must be calculated from the observations. In using formula (7) it is often possible to write $x = 0$, because it is frequently true that $t_x = t_{14}$. Rubenson's work [using centigrade temperatures] gives values for p varying from 0.34 to 0.37, depending on the month; for q from 0.07 to 0.27; and for r from 0.35 to 0.59.

The differences between local time and standard time make it necessary to write formula (5)

$$t_m = pt_7 + qt_{14} + rt_{21} + c_{Ma} \qquad (8) \quad [\text{Ma bis}]$$

where values for c_{Ma} for Swedish stations vary from −0.09 to +0.17 depending on the month and the longitude. For most of the months this formula appears satisfactory; it is of least value for May, June, July, and August. For July it is not possible to deduce a true mean without applying a constant. The formula then becomes

$$\left.\begin{array}{ll} & t_m = pt_8 + qt_{14} + rt_{21} + c \\ \text{when} & p + q + r = 1, \end{array}\right\} \qquad (9) \quad [R]$$

c being equal to 0 for all months except July. The best results for May, June, July, and August are obtained when the following pair of formulæ are adopted:

$$\left.\begin{array}{l} t_m = pt_8 + qt_{14} + rt_{21} + st_n \\ p + q + r + s = 1 \end{array}\right\} \qquad (10) \quad [S]$$

which is a special case of formula (7). Formula (9) was first used in a simplified form by placing $c = 0$ and $p = r$. This resulted in good values for t_m for Upsala, but was not satisfactory for the other four observatories. From a study of the data of the five observatories by the method of least squares, it appeared that the best means are obtained by the use of the equation

$$t_m = 0.01(pt_8 + qt_{14} + rt_{21} + st_n) \qquad (11)$$

where values for p vary from 22 to 39 depending on the month and the longitude; those for q, from 15 to 27; those for r, from 36 to 55; and those for s being 0 for all months, except from May to August, inclusive, when s varies from 0 to 11. For stations not observing the minimum temperature the values for May to August, inclusive, may be more or less adequately calculated from the equation

$$t_m = 0.01(pt_8 + qt_{14} + rt_{21} - c) \qquad (12)$$

where values for p vary from 19 to 35; those for q, from 6 to 23; those for r from 51 to 57; the values of c being 0 for all months, except July when they vary from 23 to 39.

The best means are those calculated from these values. Most of the corrections required to bring the calculated means to the true means lie between the limits −0.04°C. and +0.04°C., which are practically negligible. The extreme limits of the corrections are −0.2°C. and +0.2°C. in the great majority of cases, and it is only in isolated instances that greater corrections are necessary. These are −0.4°C. (May and August), −0.3°C. (May, June, July, and August), and +0.3°C. (September). It is striking that these large sporadic corrections were much more often negative than positive, that is the calculated mean is in the extreme cases of difference much more often too high than too low. This seems to result from the fact that the mean for the 21^h observation is at times abnormally high in the warmer months. The greatest negative corrections were −0.42°C., −0.40°C., and −0.36°C. for May, 1897, and −0.39°C. for August, 1880, all in the Upsala series. The greatest positive correction was +0.34°C. for September, 1875, in the same series.